Photonic and Quantum Interactions of Atomic-Scale Junctions

Completed Technology Project (2016 - 2020)

Project Introduction

In this proposal, the fundamental quantum and photonic interactions of bimetallic atomic-scale junctions (ASJs) will be explored, with three major space technology-related applications in focus: 1) chemical sensing, 2) smart/metamaterials, and 3) memristor-based computing. An ASJ is a type of quantum-point contact, created by electrochemically depositing silver between two nanoscale electrodes. This connection can be formed and destroyed by applying the appropriate voltage potential across the electrodes, and thus controlled to the point where the junction narrows to the width of a single atom. At this point, the junction can exhibit a phenomenon known as quantized conductance. In this region, the junction is especially sensitive to disturbances in the surrounding environment. Previous research has demonstrated the potential of a single ASJ in sensing chemicals bound to the junction at this narrowest section; this proposal will extend on that work by examining parallel and serial arrays of ASJs for chemical sensing and memristive computing, as well as the interaction of the junctions in 3-dimensional configurations with light for metamaterials. The objectives of this project are to establish control over junction growth in massively parallel arrays both through direct electrical contact and with photo-induced charging, then utilize this control to examine the potential application of these junctions in the areas described above. Junctions will be created using electrochemical deposition between conductive electrodes, which may be lithographically-defined macroscale electrodes on a wafer, a conductive AFM tip, or nanoparticles stimulated with focused lasers. Achieving these objectives would be highly significant to both NASA and the community at large. Due to the junctions' small space and weight, a massively parallel array of junctions would not take up more than a few square millimeters of area on a silicon wafer yet could perform a wide array of functions; thus, they are ideally suited to the tight weight and size requirements of terrestrially-launched space missions. The applications of ASJs in chemical sensing and memristor-based neural network applications could allow for new experiments and data analysis not possible with existing technology. In addition, the fundamental insights into quantum and photonic phenomena gained by devices that operate at room-temperature and under simple conditions would also greatly benefit the scientific community and science education.

Anticipated Benefits

Achieving these objectives would be highly significant to both NASA and the community at large. Due to the junctions' small space and weight, a massively parallel array of junctions would not take up more than a few square millimeters of area on a silicon wafer yet could perform a wide array of functions; thus, they are ideally suited to the tight weight and size requirements of terrestrially-launched space missions. The applications of ASJs in chemical sensing and memristor-based neural network applications could allow for new experiments and data analysis not possible with existing

Photonic and Quantum Interactions of Atomic-Scale Junctions

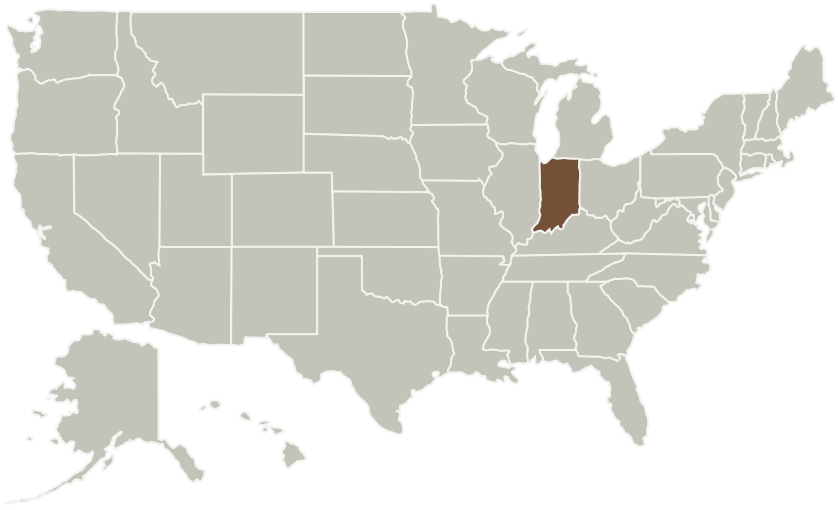
Table of Contents

Photonic and Quantum Interactions of Atomic-Scale Junctions

Completed Technology Project (2016 - 2020)

technology. In addition, the fundamental insights into quantum and photonic phenomena gained by devices that operate at room-temperature and under simple conditions would also greatly benefit the scientific community and science education.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Notre Dame(Notre Dame)	Lead Organization	Academia	Notre Dame, Indiana

Primary U.S. Work Locations
Indiana

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of Notre Dame (Notre Dame)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Paul W Bohn

Co-Investigator:

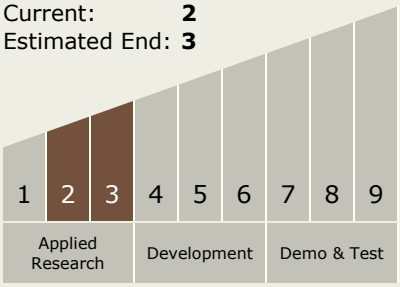
Garrison M Crouch

Photonic and Quantum Interactions of Atomic-Scale Junctions

Completed Technology Project (2016 - 2020)

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX02 Flight Computing and Avionics
  - TX02.2 Avionics Systems and Subsystems
    - TX02.2.2 Aircraft Avionics Systems

Target Destinations

Mars, Others Inside the Solar System, Foundational Knowledge